HUMIDITY CONTROL IN THE GPE APPROACH

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In last month's article we introduced new energy-smart approaches to greenhouse climate control, such as Growing by Plant Empowerment (GPE).*

These approaches utilise refined measurements and sophisticated calculations to control heating, venting, fans and screens (as well as CO_2, fogging, optionally lighting, and so on). For many growers, these systems will be too expensive, but they are useful nonetheless, as they show new directions for sustainable production.

This article is again about humidity control, but now according to these new insights. As mentioned earlier, humidity control accounts for a major part of the energy consumption in greenhouses, especially in milder conditions. Only in cold weather is energy used predominantly for temperature control. Temperature will be discussed in detail in later articles.

More than relative humidity

Conventional climate control aims to keep the relative humidity (RH) within a certain range, say 75–90%, for two reasons. Firstly, the RH must stay far below 100% to avoid condensation and so reduce fungal diseases. Secondly, low RH is needed to keep the plants active, i.e. to keep the transpiration going. The conventional approach of combined heating and venting does work, but is rather crude and uses a lot of energy.

In the new climate control, there are two separate actions: (1) preventing condensation by keeping the humidity below the dewpoint. And (2) stimulating plant transpiration by manipulating the absolute humidity of the greenhouse air. Absolute humidity, dewpoint and other units are explained below and shown in the table. Note that throughout this article 'moisture' means the same as 'water vapour'.

Condensation and dewpoint

Condensation on cold plants (or parts of plants) is a problem. Plants becoming wet at night due to condensation can be avoided by keeping them warm by closing a screen (see previous article), or by avoiding too high humidity. Traditionally, condensation is prevented by keeping the relative humidity (RH) far below 100%. The new methods, however, are based on controlling the dewpoint (DP). Dewpoint is a measure of air humidity, expressed in degrees Celsius (°C). The dewpoint tells us, at a prevailing air humidity, how cold the glass roof or a part of a plant must be to become wet from condensation.

For example, if air has a temperature of 23 °C and RH of 70%, it has a dewpoint of 17.2 °C. This means that condensation will occur on things that are 17.2 °C or colder, such as the glass roof. The plants are most likely above 17.2 °C, so they stay dry. To prevent condensation, the dewpoint (humidity in °C) of the air must be sufficiently lower than the temperature of the plants (in °C).

Dry air has a very low dewpoint. As it is unlikely that the plants will get very cold, it is unlikely they will get damp. In contrast, saturated air (with 100% RH) has a dewpoint (in °C) as high as the air temperature (in °C). In this very high humidity, most surfaces will get damp. Only surfaces warmer than the air will stay dry, for instance the heating pipes.

Medium humid air (e.g. RH 85% and temperature 23 °C) has a dewpoint of 20.3 °C. Most plants will stay dry, but there can be some cold spots where the plant temperature is below the dewpoint. The plants here are at risk of condensation and infection.

Transpiration and water balance

Transpiration control is different too in the new-style climate control. It does not aim for a certain relative humidity (RH), humidity deficit (HD) or vapour pressure deficit (VPD). Instead, it aims directly for a certain level of plant transpiration. To do this, the computer calculates the water balance, based on absolute humidity inside, outside, and above the screen (if closed). If the transpiration rate is not on target, the computer adjusts the devices (heating, vents, etc). This is much more energy-efficient than drastically increasing heating and venting based on RH, as in conventional control. Absolute humidity (AH) is the amount of water vapour in grams per amount of air, which is a more solid unit than relative humidity (RH).

The calculation of transpiration is briefly outlined here. When mechanical ventilation is used, such as extractor fans or climate units in semi-closed greenhouses, the rate of air exchange can be calculated accurately. It is then simple to calculate how much moisture is removed from the greenhouse air to the outside, and from this determine the transpiration rate. When natural ventilation through vents is used, the air exchange rate cannot be determined accurately. The transpiration is then calculated from the AH and the difference in plant temperature and air temperature.

Irrespective of the type of ventilation system, if the difference in AH between inside and outside is larger, then less ventilation is needed to remove enough water vapour, and to keep the ventilation going. Then less energy is lost.

In summary

The new control software obtains information about dewpoint (for preventing condensation) and water balance (for transpiration control) and a few other measures, and then decides how to adjust the devices, e.g. the screen, vents, fans, climate units and/or heating pipes. This saves energy.

Different units

In this article we used different units for different purposes. Relative Humidity (RH in %) is the easiest, but is temperature-dependent. For condensation, the best unit is Dewpoint (DP), as discussed above. For water balance and transpiration, the best unit is Absolute Humidity (AH) in gram moisture per m^3 air or in gram moisture per kg of dry air (the latter is sometimes called Specific Humidity, SH). Conventional greenhouse control often looks at Humidity Deficit (HD) or Vapour Pressure Deficit (VPD). Higher moisture deficit means drier air, which draws more water out of the leaves. Conversion from one unit to another is different at different temperatures, as shown in the table. A helpful tool for humidity units can be found at http://gpe.letsgrow.com/psychro.

TABLE: Units for air humidity.

RH = Relative Humidity in % of saturation.

AH = Absolute Humidity in gram moisture per m^3 of air.

SH = Specific Humidity (sometimes called Absolute Humidity) in gram moisture per kg air.

VPD = Vapour Pressure Deficit in kPa.

DP = dewpoint in °C.

Conversion depends on the temperature.

	10°C				20°C				30°C			
RH	AH	SH	VDP	DP	AH	SH	VDP	DP	AH	SH	VDP	DP
%	g/m^3	g/kg	kPa	°C	g/m^3	g/kg	kPa	°C	g/m^3	g/kg	kPa	°C
100	9.4	7.6	0.0	10.0	17.4	14.5	0.0	20.0	30.5	26.5	0.0	30.0
95	8.9	7.2	0.1	9.2	16.5	13.7	0.1	19.2	28.9	25.1	0.2	29.1
90	8.5	6.8	0.1	8.4	15.6	13.0	0.2	18.3	27.4	23.8	0.4	28.2
85	8.0	6.4	0.2	7.6	14.7	12.3	0.4	17.4	25.9	22.4	0.6	27.2
80	7.5	6.1	0.3	6.7	13.9	11.6	0.5	16.4	24.3	21.1	0.9	26.2
75	7.1	5.7	0.3	5.8	13.0	10.8	0.6	15.4	22.8	19.8	1.1	25.1
70	6.6	5.3	0.4	4.8	12.1	10.1	0.7	14.4	21.3	18.4	1.3	23.9
60	5.6	4.5	0.5	2.6	10.4	8.7	0.9	12.0	18.3	15.8	1.7	21.4
50	4.7	3.8	0.6	0.1	8.7	7.2	1.2	9.3	15.2	13.1	2.1	18.4
40	3.8	3.0	0.7	-2.9	6.9	5.8	1.4	6.0	12.2	10.5	2.6	14.9
30	2.8	2.3	0.9	-6.7	5.2	4.3	1.6	1.9	9.1	7.9	3.0	10.5

**New approaches to greenhouse climate control*

There are several new approaches, for example GPE ('Growing by Plant Empowerment'), HNT ('the New Way of Growing'), semi-closed greenhouse systems and more. Full implementation requires investment in thermal screens, fans, measuring boxes above the screen, sensors for plant temperature, new software, as well as time for training. It can be an interesting and useful exploration for energy-intense greenhouses that produce high value crops getting the balance right so that investments are earned back by energy saving and by enhanced production and improved quality. For more information on GPE, see www.plantempowerment.com